MODEL HWA-2021-3 Auto Patch Encoder

HEATHKIT®

ASSEMBLY MANUAL

HEATHKIT®

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PRICE $2.00

595-1784

Model HWA-2021-3 Auto Patch Encoder

HEATH COMPANY • BENTON HARBOR, MICHIGAN

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The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information	(616) 982-3411
Credit	(616) 982-3561
Replacement Parts	(616) 982-3571
Technical Assistance:	
R/C, Audio, and Electronic Organs	(616) 982-3310
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During your first ninety (90) days of ownership, Heath Company will replace or repair free of charge — as soon as practical — any parts which are defective, either in materials or workmanship. You can obtain parts directly from Heath Company by writing us or telephoning us at (616) 982-3571. And we'll pay shipping charges to get those parts to you — anywhere in the world.

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If a defective part or error in design has caused your Heathkit product to malfunction during the warranty period, through no fault of yours, we will service it free upon delivery at your expense to the Heath factory, Benton Harbor, Michigan, or to any Heathkit Electronic Center (units of Schlumberger Products Corporation), or through any of our authorized overseas distributors.

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HEATH COMPANY
BENTON HARBOR, MI. 49022

Prices and specifications subject to change without notice.

Assembly and Operation of the

HEATHKIT®

AUTO PATCH ENCODER

MODEL HWA-2021-3

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PARTS LIST

Check each part against the following list. Make a check (✓) in the space provided as you identify each part. The key numbers correspond to the numbers in the Parts Pictorial. Any part that is packed in an individual envelope should be returned to the envelope after it has been identified. Keep these parts in the envelopes until they are called for in the assembly step. Do not throw away any packing material until you account for all the parts.

Each circuit part in this kit has its own "Circuit Component Number" (R102, C104, IC103, etc.). This is a specific number for only that one part. The purpose of these numbers is to help you easily identify the same part in each section of this Manual. These numbers, which are especially useful if a part has to be replaced, appear:

- In the Parts List;
- At the beginning of each step where a component is installed;
- In some illustrations;
- In the sections at the rear of this Manual.

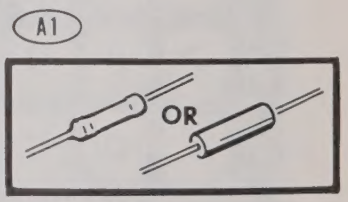
To order a replacement part, always include the Part Number. Use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of this Manual. For pricing information, refer to the separate "Heath Parts Price List."

KEY No.	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.

RESISTORS

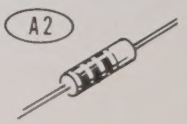
1/8-Watt

NOTE: The following resistors have a 1% tolerance. The resistors have a temperature coefficient (TC) of 100 parts per million per °C(100 PPM/°C).



A1 ( )	1	3400 Ω (3.4k)	2-51-11	R106
A1 ( )	1	3900 Ω (3.9k)	2-39-11	R107
A1 ( )	1	5370 Ω (5.37k)	2-50-11	R102
A1 ( )	1	5760 Ω (5.76k)	2-17-11	R101
A1 ( )	1	6110 Ω (6.11k)	2-49-11	R103
A1 ( )	1	6530 Ω (6.53k)	2-48-11	R104
A1 ( )	1	8900 Ω (8.9k)	2-26-11	R111
A1 ( )	1	10.1 kΩ	2-40-11	R105
A1 ( )	1	17.8 kΩ	2-14-11	R108

1/4-Watt

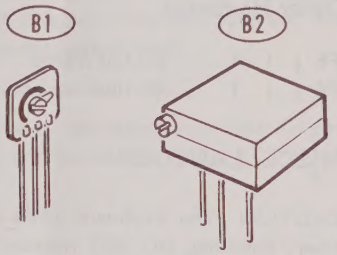


NOTE: The following resistors have a 10% tolerance. This is indicated by a fourth color band of silver.

A2 ( )	2	100 Ω (brown-black-brown)	1-1-12	R113, R114
A2 ( )	1	3300 Ω (orange-orange-red)	1-6-12	R119
A2 ( )	1	10 kΩ (brown-black-orange)	1-9-12	R115

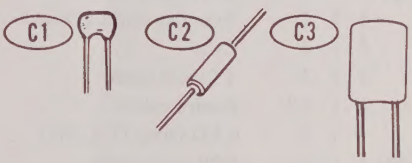
KEY No.	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.
1/4-Watt (cont'd.)				
A2 ( )	1	100 kΩ (brown-black-yellow)	1-32-12	R117
A2 ( )	2	330 kΩ (orange-orange-yellow)	1-15-12	R116, R118
A2 ( )	1	1 MΩ (brown-black-green)	1-19-12	R121

CONTROLS



B1 ( )	1	10 kΩ	10-1039	R122
B2 ( )	2	10 kΩ, 25 turns	10-1065	R109, R112

CAPACITORS

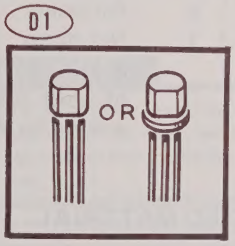


C1 ( )	3	.047 μF (473) ceramic	21-182	C105, C106, C109
C2 ( )	1	.047 μF tantalum	25-209	C114
C2 ( )	3	.22 μF tantalum	25-210	C107, C108, C113
C2 ( )	2	18 μF tantalum	25-161	C103, C104
C3 ( )	3	.033 μF Mylar*	27-138	C101, C102, C112
C3 ( )	1	.01 μF Mylar	27-74	C111

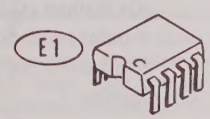
TRANSISTOR-INTEGRATED CIRCUITS

NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways:

1. Part number.
2. Type number. (On integrated circuits this refers only to the numbers; the letters may be different or missing.)
3. Part number and type number.
4. Part number with a type number other than the one listed.

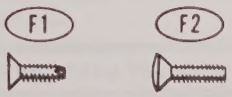


D1 ( )	1	X29A829 transistor	417-201	Q101
E1 ( )	1	LM301A integrated circuit	442-39	IC103
E1 ( )	2	NE555V integrated circuit	442-53	IC101, IC102



HARDWARE

#4 Hardware

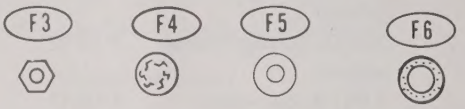


F1 ( )	4	#4 x 5/16" self-tapping screw	250-1153
F2 ( )	4	4-40 x 7/16" oval head screw	250-1233

*Registered Trademark, DuPont

KEY No.	QTY.	DESCRIPTION	PART No.	CIRCUIT Component No.

#4 Hardware (cont'd.)



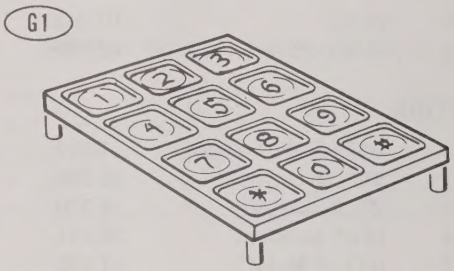
F3 ( )	8	4-40 nut	252-15
F4 ( )	4	#4 lockwasher	254-9

Other Hardware

F5 ( )	4	#3 flat washer	253-94
F6 ( )	1	#5 fiber washer	253-43

MISCELLANEOUS

CAUTION: The keyboard (#64-780) can be damaged by rough handling. DO NOT remove it from its box until you are instructed to do so in a step.

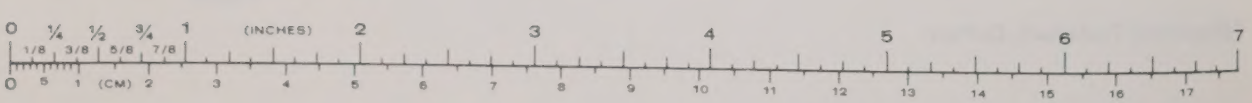


LED101

G1 ( )	1	Keyboard	64-780
( )	1	Encoder circuit board	85-1668-1
( )	1	Case	95-607
( )	1	1" steel blade	205-778
( )	7"	8-wire cable	347-55
( )	1	LED lamp (TIL209)	412-79
G2 ( )	3	PCB connector	432-120
G3 ( )	8	Pin socket	432-932
( )	1	Nut starter	490-5
( )		Solder (Additional 4-1/2' rolls of solder, #331-6, can be ordered for 25 cents each.)	

PRINTED MATERIAL

( )	1	Blue and white label	391-34
( )	1	Parts Order Form	597-260
( )	1	Kit Builders Guide	597-308
( )	1	Assembly Manual (See front cover for part number.)	



ASSEMBLY NOTES

Before you start to assemble this kit, read the wiring, soldering, and step-by-step assembly information in the "Kit Builders Guide."

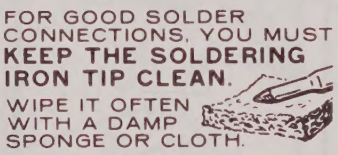
When you perform the steps in the circuit board Pictorials, position each part as shown. Follow the instructions carefully and read the entire step before you perform each operation.

Due to the small area around some of the circuit board holes, and the small area between the foils, be very careful to prevent solder bridges between adjacent foils. Use a minimum amount of solder and a small tip soldering iron of not over 25 watts. Allow the iron to reach operating temperature; then apply it only long enough to make a good solder connection.

All the resistors will be identified by the resistance value in ohms (Ω), kilohms (kΩ) or megohms (MΩ). The 1/4-watt resistors have a 10% tolerance and will be identified by the color code. The 1/8-watt precision resistors, however, will have the value stamped on the resistor body.

Capacitors will be identified by the capacitance value (in μF) and type (ceramic, Mylar, and tantalum).

STEP-BY-STEP ASSEMBLY



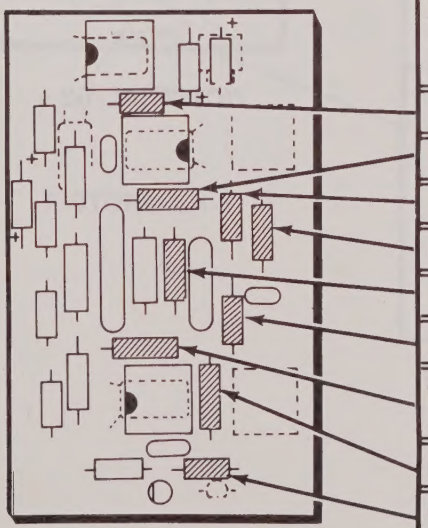
START

The circuit board has foil on both sides. One side has part outlines printed on it; this side will be called the "printed side." The dashed part outlines indicate the parts that will be installed on the other side, called the "foil side," of the circuit board. DO NOT solder to the printed side of the circuit board unless you are instructed to do so.

(✓) Position the circuit board as shown with the printed side up.

Mount all parts close to the circuit board. When you solder a lead to the foil, be careful that you do not bridge solder across to another foil. Also, when you install a part on the circuit board, make sure that you do not cover up an unused hole where another part will be installed later.

Solder the leads to the foil as you install each part and cut off the excess lead lengths.



CONTINUE

SAFETY WARNING: Avoid eye injury when you cut off the excess lead lengths. Hold the leads so they cannot fly toward your eyes.

(✓) R121: 1 MΩ (brown-black-green).

(✓) R105: 10.1 kΩ, 1%, precision.

(✓) R114: 100 Ω (brown-black-brown).

(✓) R111: 8900 Ω (8.9k), 1%, precision.

(✓) R107: 3900 Ω (3.9k), 1%, precision.

(✓) R113: 100 Ω (brown-black-brown).

(✓) R101: 5760 Ω (5.76 k), 1%, precision.

(✓) R108: 17.8 kΩ, 1%, presision.

(✓) R115: 10 kΩ (brown-black-orange).

PICTORIAL 1-1

START

NOTE: When you install tantalum capacitors, always match the plus (+) marked end of the capacitor with the plus (+) mark on the circuit board.

( ) C108: .22 µF tantalum.

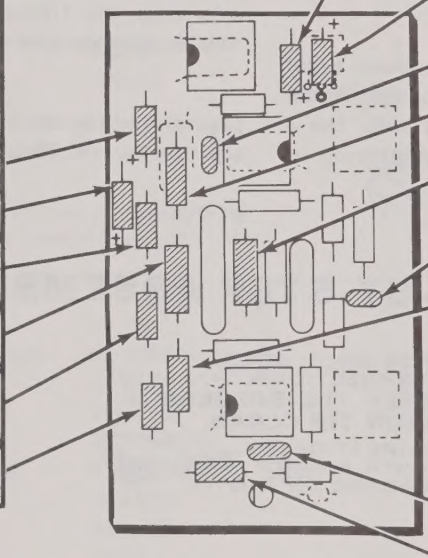
( ) C107: .22 µF tantalum.

( ) R117: 100 kΩ (brown-black-yellow).

( ) R103: 6110 Ω, (6.11 k), 1%, precision.

( ) R118: 330 kΩ (orange-orange-yellow).

( ) R116: 330 kΩ (orange-orange-yellow).



CONTINUE

( ) C113: .22 µF tantalum.

( ) C114: .047 µF tantalum. NOTE: Use the lower hole indicated by the heavy outline.

( ) C106: .047 µF (473) ceramic.

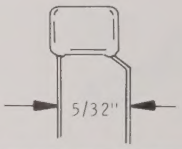
( ) R102: 5370 Ω, (5.37 k), 1%, precision.

( ) R106: 3400 Ω (3.4k), 1%, precision.

( ) C109: .047 µF (473) ceramic.

( ) R104: 6530 Ω, (6.53 k), 1%, precision.

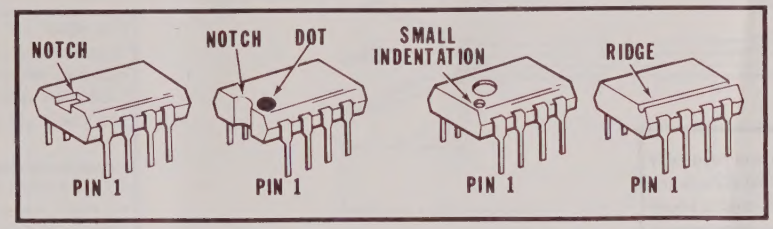
NOTE: Before you install the next capacitor, form its leads as shown using a pair of long-nose pliers.



( ) C105: .047 µF (473) ceramic.

( ) R119: 3300 Ω (orange-orange-red).

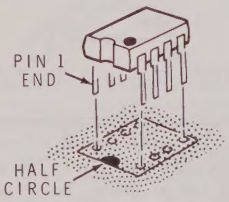
PICTORIAL 1-2



Detail 1-3A

START

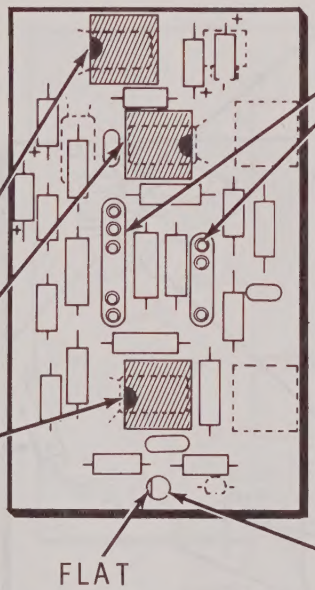
NOTE: In the next three steps, refer to Detail 1-3A and locate the pin 1 end of the IC. Then install the IC with the pin 1 end over the half circle on the circuit board. Make sure that all of the IC pins go through the circuit board.



( ) IC103: LM301A IC (#442-39).

( ) IC102: NE555V IC (#442-53).

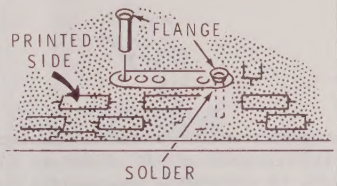
( ) IC101: NE555V IC (#442-53).



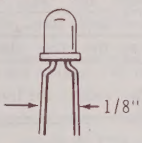
PICTORIAL 1-3

CONTINUE

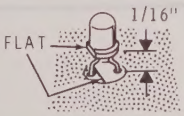
( ) Install eight pin sockets (#432-932). Push each socket through the circuit board hole from the printed side. Then solder the socket to the other side of the circuit board. DO NOT cut these sockets off on the foil side of the circuit board.



NOTE: Before you install the LED (#412-79), form both leads as shown. Use a pair of long-nose pliers.



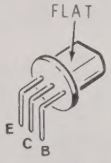
( ) LED 101: Note the flat on one side of the LED. Be sure to position the LED so the flat is over the outline of the flat on the circuit board. Space the LED 1/16" off the circuit board.



START

Turn the circuit board over and position it as shown. Solder the following parts to the foil side (this side) of the circuit board unless you are instructed to do otherwise.

(√) Q101: X29A829 transistor (#417-201). Position the transistor with its flat side up. Then bend the leads down. Insert the transistor leads through the circuit board and solder the leads to the foil. The transistor lead callouts are printed on the other side of the circuit board.



(√) Locate three .033 µF and one .01 µF (.01k) Mylar capacitors. Cut the leads of each capacitor to 1/4".

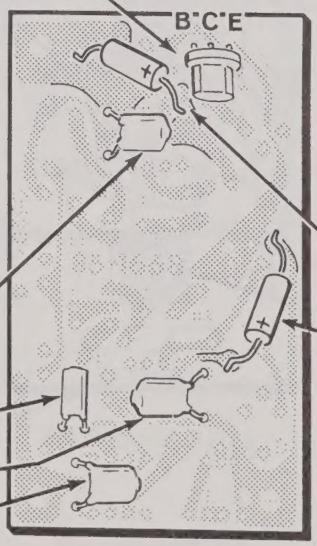
NOTE: Install the next four capacitors as follows: Insert the leads through the circuit board only until they start to protrude from the other side. Then bend the capacitor over against the circuit board and solder the leads to the foil.

(√) C101: .033 µF Mylar.

(√) C111: .01 µF (.01k) Mylar.

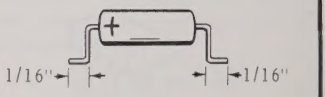
(√) C102: .033 µF Mylar.

(√) C112: .033 µF Mylar.



CONTINUE

(√) Locate two 18 µF tantalum capacitors. Cut the leads of each capacitor to 1/4". Then bend a 1/16" foot on each lead, as shown.

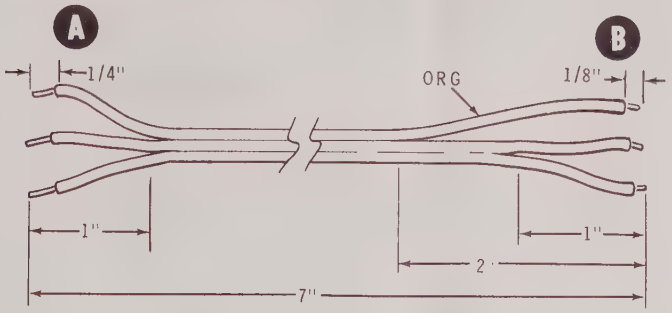


NOTE: To install each of the next two capacitors, position it with the plus (+) marked end as shown. Then solder the leads directly to the indicated foil pads, as there are no empty holes at these locations.

(√) C103: 18 µF tantalum.

(√) C104: 18 µF tantalum.

PICTORIAL 1-4



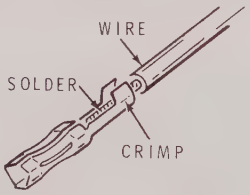
Detail 1-5A

START

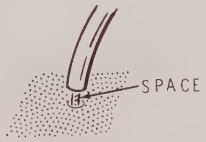
( ) Locate the 8-wire flat cable and separate the brown, red, and orange wires from the rest of the cable. Do not separate these three wires from each other. Discard the 5-wire flat cable.

( ) Refer to Detail 1-5A and prepare the 3-wire flat cable as shown. Twist the strands at each wire end together and melt a small amount of solder on the bare wire ends to hold the strands together.

( ) Crimp and solder female connectors onto the three wires at end B of the 3-wire flat cable.

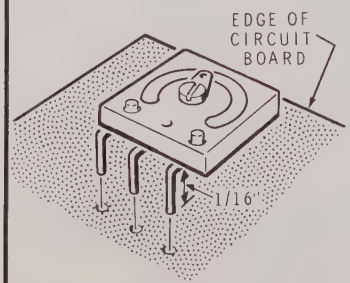


( ) Connect the other end of the 3-wire flat cable to the circuit board as shown. Leave a space between the wire's insulation and the foil to allow solder to flow around the wire.

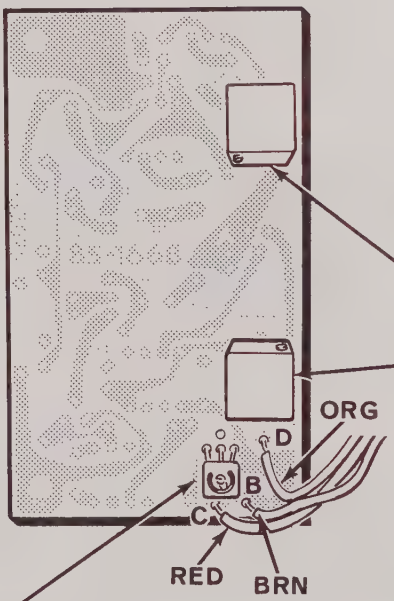


NOTE: In the following step, bend each lead close to the control body.

( ) R122: 10 kΩ control. First bend the leads at a right angle to the control. Then cut the leads to 1/16".



( ) Solder the control leads to the circuit board foil.

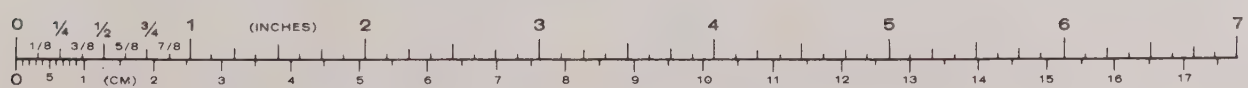


PICTORIAL 1-5

CONTINUE

( ) R109: 10 kΩ, 25-turn control. Insert the pins through the circuit board and solder them on the printed side of the circuit board.

( ) R112: 10 kΩ, 25-turn control. Install this control in the same manner.



CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) There are 8 unused smaller holes and 4 unused larger holes.

( ) Unsoldered connections.

( ) "Cold" solder connections.

( ) Solder bridges between foil patterns.

( ) Protruding leads. No lead should be longer than 1/16".

( ) Integrated circuits for the proper type and installation.

( ) Transistor for the proper installation.

( ) Tantalum capacitors for the correct position of the positive (+) end.

( ) LED lamp for the correct position of the "flat side."

The keyboard will be installed later. Proceed to the "Initial Tests."

INITIAL TESTS

The purpose of the "Test" section of this Manual is to make sure your Auto Patch Encoder operates and will not be damaged as a result of a wiring error. A transistor or integrated circuit, for example, could be destroyed instantly by a short circuit that causes excessive current.

You will use an ohmmeter to make resistance measurements on the circuit board. This test will tell if a short circuit or open circuit exists, which might cause a problem when power is applied to the circuit board. If you cannot obtain the proper ohmmeter reading in the following steps, refer to the "In Case of Difficulty" section. DO NOT apply power to the circuit board until the difficulty has been corrected.

NOTE: Use a vacuum tube voltmeter (VTVM) or a volt-ohmmeter (VOM) to make the resistance checks in the following steps (solid-state ohmmeters do not furnish a voltage high enough to make the diodes conduct in the circuit being tested). Make sure you have the ohmmeter set correctly, since the range setting influences the meter reading when a diode is in the circuit.

To make this test, first touch the test leads of your ohmmeter together and vary the OHMS ADJUST control to obtain a "0" reading on the meter. If you get this reading in any of the resistance checks that follow, it will mean that there is a short circuit somewhere in the circuit you are checking.

In any of these resistance checks, a meter reading lower in value than the one shown in the chart might indicate a solder bridge across adjacent foils on the circuit board. A meter reading that is higher than the one shown might indicate a poor solder connection or a faulty or improperly installed component.

NOTE: The internal wiring of most ohmmeters is such that the positive terminal of the meter battery is connected to the positive (red) test lead and the negative battery terminal is connected to the negative (black) test lead. In some ohmmeters this wiring is reversed and erroneous readings will be obtained when you make the following measurements. Reverse the ohmmeter leads if the measurements do not check out correctly the first time.

( ) Set your ohmmeter to the RX100 range.

IMPORTANT: The ohmmeter readings in the following chart were made with a Heathkit Model IM-18 VTVM.

Connect your ohmmeter leads as directed and make the measurements shown on the following chart.

OHMMETER TEST POINTS		RESISTANCE IN OHMS
COMMON LEAD	POSITIVE (+) LEAD	
Brown lead	Red lead	INF
Brown lead	Orange lead	4-6 kΩ

If you do not obtain the proper ohmmeter readings, look for solder bridges or foil bridges on the circuit board and refer to "In Case of Difficulty" on Page 20.

This completes the tests. Disconnect the meter leads and proceed to "Final Assembly."

FINAL ASSEMBLY

Refer to Pictorial 2-1 for the following steps.

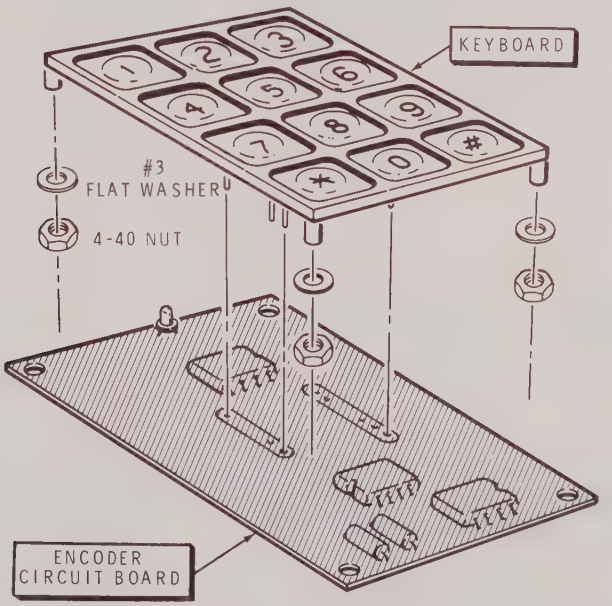
(√) Remove the keyboard (#64-780) from its box.

CAUTION: DO NOT push any of the keyboard buttons until you have completed the next two steps.

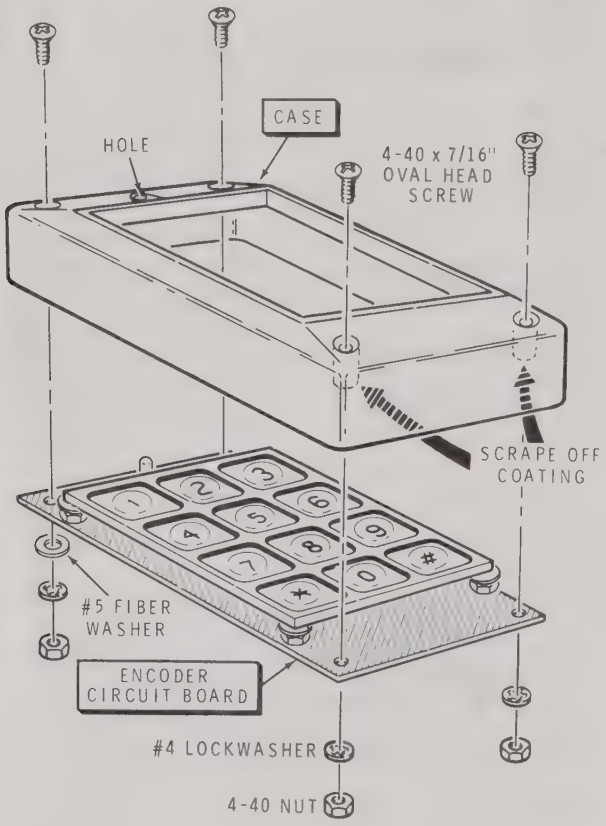
( ) Install a #3 flat washer on one of the keyboard bosses. Then, using a pair of long-nose pliers, start a 4-40 nut on this boss to form threads. Carefully tighten the nut. DO NOT overtighten, as you may strip the threads.

(√) Similarly, install a #3 flat washer and a 4-40 nut on each of the three remaining bosses.

(√) Position the keyboard and encoder circuit board as shown. Then insert the keyboard pins into the proper pin sockets on the circuit board. Be sure the keyboard bosses are pressed tightly down against the circuit board. Carefully inspect the space between the keyboard and the circuit board for any parts, which might interfere with the keyboard. For example, if a ceramic capacitor interferes, bend it over.



PICTORIAL 2-1



PICTORIAL 2-2

Refer to Pictorial 2-2 for the following step.

(√) Use a penknife to scrape off the conductive coating from the end and the side of each boss at the indicated locations. NOTE: Make sure you remove enough of this coating to avoid shorting out foil on the encoder circuit board after it has been installed in the case.

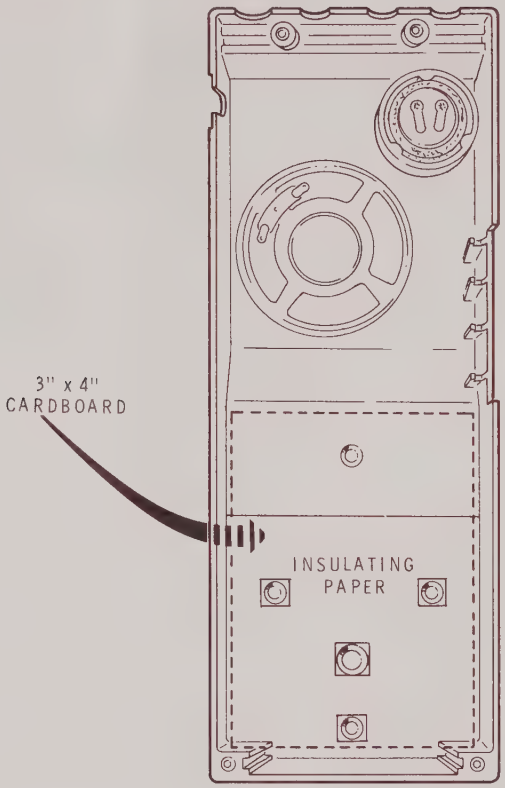
( ) Position the case over the encoder circuit board as shown. Make sure the LED lamp on the circuit board enters the hole in the cover; then secure the circuit board to the case with 4-40 x 7/16" oval head screws, #4 lockwashers, and 4-40 nuts at the locations shown. Also install a #5 fiber washer at the indicated location.

(√) Locate your Transceiver.

NOTE: If you intend to use your Auto Patch Encoder with the Heath HW-2021 Transceiver, proceed with the following steps. However, if you will be using a different transceiver, first refer to Page 19 of this Manual to identify each wire of the Encoder's 3-wire cable. Then proceed with the proper steps in the "Adjustments" section of this Manual.

( ) Remove the screws holding the Transceiver case halves together. Save the screws.

( ) Carefully disconnect each wire and cable going from the Transceiver case top to the main circuit board; pull the PCB connector on the end of each wire from the circuit board connector pin.



PICTORIAL 2-3

Refer to Pictorial 2-3 for the following steps.

( ) Cut a 3" x 4" piece of cardboard from the shipping carton.

( ) Place the case top up-side-down with the cardboard under the case top as shown.

( ) Use a pin or some small pointed instrument to indent the five knockouts in the case top. Then use a pen knife and cut a hole about 5/16" square, in the insulating paper at the four locations shown in the Pictorial.

( ) Turn the case top over, remove the cardboard and push out the knockouts from the front of the case top. Use an awl, or other pointed instrument to push out the knockouts, or if you prefer, you can drill them out. Refer to the illustration for the mounting template, on Page 18, for the proper hole size.

NOTE: The blue and white label that will be installed in the following steps shows the Model number and Production Series number of your kit. Refer to these numbers in any communications with the Heath Company.

( ) Carefully peel away the paper backing from the blue and white label. Then press the label onto the cover of this Manual.

This completes the "Final Assembly." Proceed to "Adjustments."

ADJUSTMENTS

You can use either of two methods to adjust the tones from your Encoder to the correct frequencies. If you have access to an AC coupled frequency counter, perform the steps under Method #1. This is the preferred method. If a frequency counter is not available, perform the steps under Method #2 if you live near a repeater site where a decoder is available to decode the tone frequencies produced.

METHOD #1

NOTE: Make sure your Transceiver is turned off.

Refer to Pictorial 3-1 for the following steps.

( ) Position the Transceiver case halves so you have access to the main circuit board in the Transceiver case bottom.

( ) Unsolder the end of the orange wire connected to switch SW1 lug 2.

( ) Temporarily connect this end of the orange wire to switch SW1 lug 1.

( ) Position the encoder assembly near the transceiver main circuit board as shown in the Pictorial.

NOTE: You will connect the brown and the orange wires coming from the encoder circuit board to the transceiver main circuit board in the following steps. Push the PCB connector on the end of each wire onto the connector pin mounted on the main circuit board.

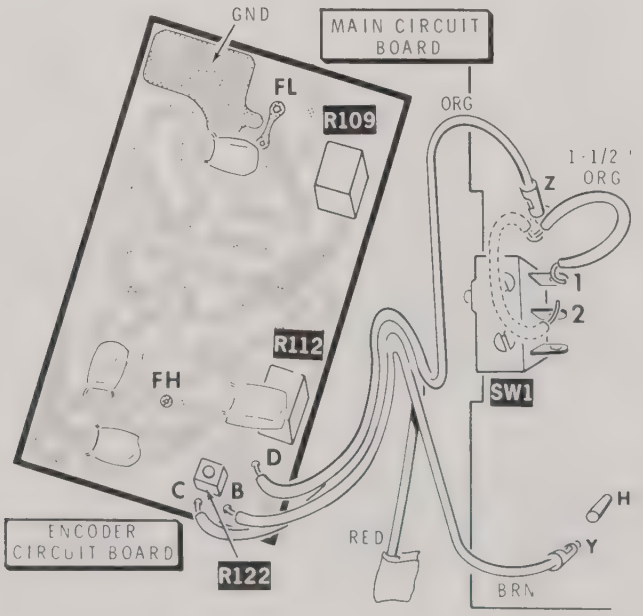
( ) Brown wire to Y.

( ) Orange wire to Z.

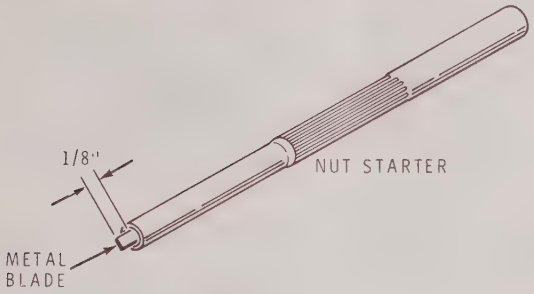
( ) Wrap a piece of tape around the connector on the free end of the red wire.

( ) Temporarily solder a short cut-off component lead to foil pad FL on the encoder circuit board. NOTE: It may be necessary to lift the .033 μF Mylar capacitor.

( ) Connect the shield lead of the AC coupled frequency counter test cable to ground (GND) and the inner lead to the component lead at FL on the encoder circuit board.



PICTORIAL 3-1



Detail 3-1A

( ) Refer to Detail 3-1A and use a pair of pliers to push the 1" steel blade into the smaller end of the nut starter until 1/8" remains exposed. Use this tool to adjust the controls on the circuit board.

NOTE: If you do not obtain the correct frequency readings in the following steps, refer to the "In Case of Difficulty" section on Page 20.

( ) Turn the Transceiver on.

( ) Press the "#" key and adjust control R109 on the encoder circuit board until the frequency counter reads 941 Hz ±2 Hz.

NOTE: In the following steps you will measure the frequency of each of the remaining tones generated in the Low Tone Oscillator circuit.

( ) Press the "9" key. The frequency counter should read 852 Hz ±13 Hz.

( ) Press the "6" key. The frequency counter should read 770 Hz ±12 Hz.

( ) Press the "3" key. The frequency counter should read 697 Hz ±11 Hz.

( ) Turn the Transceiver off.

( ) Disconnect the inner lead of the frequency counter test cable from the lead at foil pad FL on the circuit board.

( ) Unsolder and remove the lead previously connected to foil pad FL.

( ) Temporarily solder this lead to foil pad FH. NOTE: It may be necessary to lift the .033 μF Mylar capacitor.

( ) Connect the inner lead of the frequency counter test cable to the lead at FH.

( ) Turn the Transceiver on.

( ) Press the "#" key and adjust control R112 on the encoder circuit board until your frequency counter reads 1477 Hz ±2 Hz.

NOTE: In the following steps you will measure the frequency of each of the remaining tones generated in the High Tone Oscillator circuit.

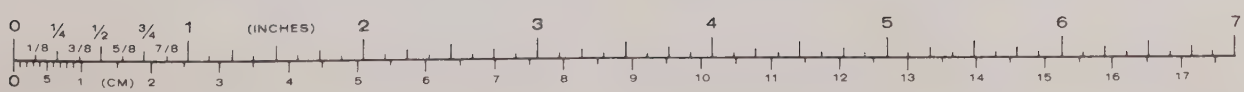
( ) Press the "0" key. The frequency counter should read 1336 Hz ±20 Hz.

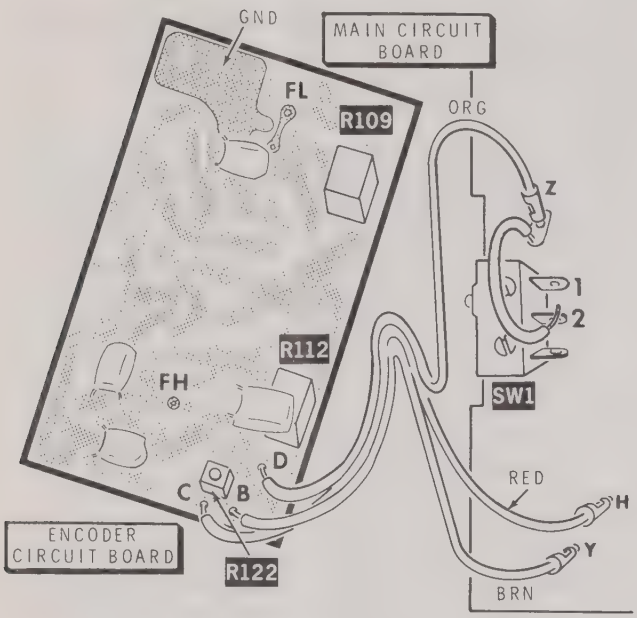
( ) Press the "*" key. The frequency counter should read 1209 Hz ±18 Hz.

( ) Turn the Transceiver off.

( ) Unsolder and discard the lead previously connected to foil pad FH.

This completes the adjustments of the tone frequencies. Proceed to "Level Adjustment."





PICTORIAL 3-2

METHOD #2

NOTE: You will need the assistance of somebody familiar with the facilities at your nearby repeater site when you perform the adjustments using this method.

( ) Route the 3-wire cable coming from the encoder circuit board through the 1/4" hole in the transceiver case top.

Refer to Pictorial 3-2 for the following steps.

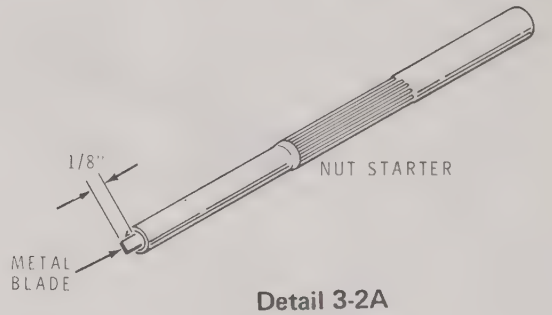
NOTE: You will connect the wires coming from the encoder circuit board to the transceiver main circuit board in the following steps. Push the PCB connector on the end of each wire onto the connector pin mounted on the main circuit board.

( ) Brown wire to Y.

( ) Red wire to H.

( ) Orange wire to Z.

( ) Replace the PTT switch actuator and install the case top over the case bottom of the Transceiver. Be sure the top is seated properly on the case bottom and no wires or cables are being pinched; then secure the case top to the case bottom with the four screws set aside earlier.



Detail 3-2A

( ) Refer to Detail 3-2A and use a pair of pliers to push the 1" steel blade into the smaller end of the nut starter until 1/8" remains exposed. Use this tool to adjust the controls on the circuit board.

NOTES:

1. If you do not obtain the correct frequency readings in the following steps, refer to the "In Case of Difficulty" section on Page 20.

2. The following adjustments can conveniently be made at the repeater site (or where the repeater receiver is located).

( ) Turn controls R109 and R112 thirty turns counterclockwise.

( ) Turn control R122 to midrange.

( ) Turn the Transceiver channel selector switch (SW201) to the proper position.

( ) Make sure slide switch SW2 is set so the red dot is showing.

( ) Turn the Transceiver on.

( ) Push the # sign on the encoder keyboard and at the same time, press the Transceiver PTT button.

( ) With the PTT button pressed and the # sign pushed, turn control R109 slowly in a clockwise direction until the decoder indicator for the low tone frequency (941 Hz) "turns on." Continue to turn this control in the same direction until the indicator "turns off." Count the number of turns between these two settings. Then adjust control R109 to the center of this range.

( ) In the same manner, adjust control R112 for the high tone frequency (1477 Hz).

NOTE: If the decoder has indicators for the remaining tone frequencies produced by the encoder, two of these indicators will "turn on" when any one of the keyboard buttons is being pushed and the correct frequencies are generated. The chart on Page 23 shows what frequencies are generated in the encoder.

( ) Refer to the chart on Page 23 and push each of the remaining keyboard buttons. Make sure the two proper indicators "turn on" as shown in the chart.

This completes the adjustments of the tone frequencies. Proceed to "Level Adjustment."

LEVEL ADJUSTMENT

IMPORTANT: Before you complete the following steps, make sure the LEVEL control in your Transceiver is adjusted according to your Manual.

The LEVEL control will now be adjusted to insure you that the transmitted signal is properly modulated when you are using the Auto Patch Encoder.

NOTE: If you used Method #1 when you made the adjustments in this section of the Manual, complete the following step. If you used Method #2, disregard the next step.

( ) Remove the piece of tape wrapped around the connector on the free end of the red wire. Then push the connector onto connector pin H on the main circuit board.

( ) If you have not already done so, turn control R122 on the encoder circuit board to midrange.

( ) Turn the Transceiver on.

( ) Check to see that the LED lamp lights when any one of the keyboard signs is pushed.

Use one of the following methods, listed in the order of accuracy, to adjust the level control.

1. While you key the transmitter, and at the same time push the # sign on the Encoder keyboard, adjust the LEVEL control (R122) for 4.5 to 5 kHz of FM deviation using a deviation monitor meter.

2. If a deviation monitor meter is not available, use on-the-air checks with other amateur operators. Check with three or four stations to get a consensus of opinion on the recaptured audio in their receivers. Then adjust the LEVEL control until they say your deviation is correct.

NOTE: You may have to readjust the LEVEL control slightly to gain access to the auto patch.

( ) Turn the Transceiver off.

NOTE: If you used Method #1 when you made the adjustments in this section of the Manual, complete the following steps. If you used Method #2, disregard these steps.

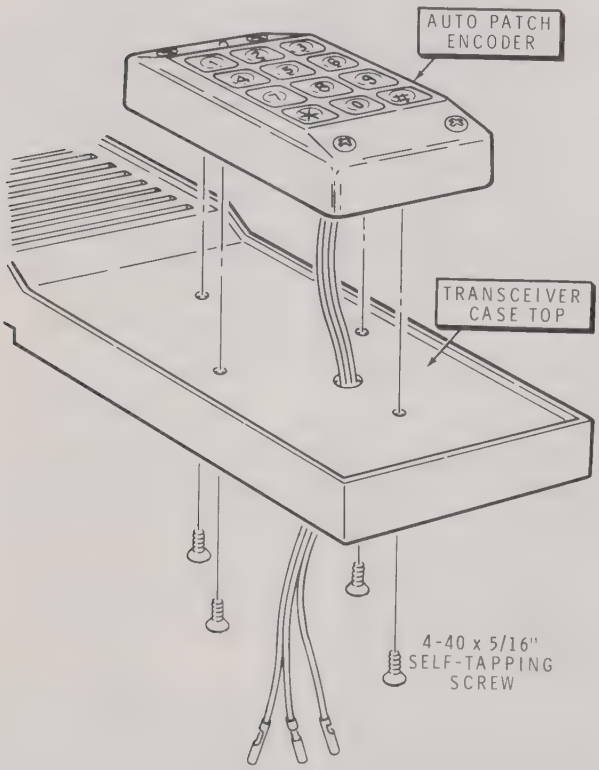
( ) Unsolder the end of the orange wire connected to switch SW1 lug 1.

( ) Reconnect this end of the orange wire to switch SW1 lug 2.

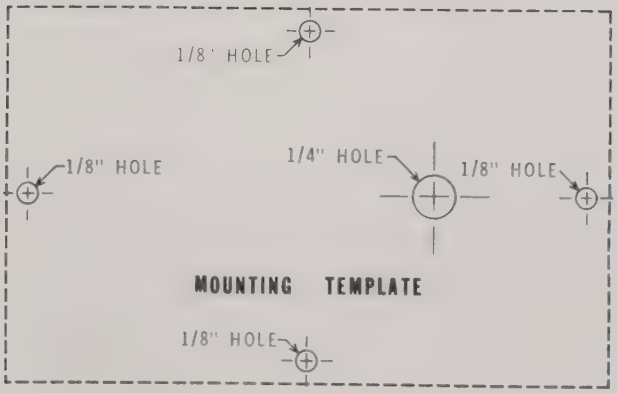
This completes the "Adjustments" of your Auto Patch Encoder. Proceed to "Installation."

INSTALLATION

To install your Auto Patch Encoder in your Heathkit 2-meter Handheld Transceiver, perform the following steps. To install your Encoder in a different transceiver, perform the steps under "Typical Transceiver Installation" and modify your transceiver as necessary to fit your application.



PICTORIAL 3-3



NOTE: If you used Method #1 when you made the adjustments in this section of the Manual, complete the following step. If you used Method #2, disregard the next step.

( ) Carefully disconnect the brown, red, and orange wires going from the encoder circuit board to the transceiver circuit board.

Refer to Pictorial 3-3 for the following steps.

( ) If you have not already done so, route the 3-wire cable coming from the encoder circuit board through the 1/4" hole in the transceiver case top.

( ) Fasten the Auto Patch Encoder to the transceiver case top with four #4 self-tapping screws.

Refer to Pictorial 3-4 for the following steps.

NOTE: You will connect the 3-wire cable coming from the encoder circuit board to the transceiver main circuit board in the following steps. Push the PCB connector on the end of each wire onto the connector pin mounted on the main circuit board as follows:

( ) Brown wire to Y.

( ) Red wire to H.

( ) Orange wire to Z.

( ) Refer to the HW-2021 Assembly Manual and reconnect all wires and cables previously disconnected from the transceiver main circuit board.

( ) Replace the PTT switch actuator and install the case top over the case bottom of the transceiver. Be sure the top is seated properly on the case bottom and no wires or cables are being pinched. Also be sure the 3-wire cable lays flat across the transceiver battery pack.

Typical Transceiver Installation

Perform the following steps.

1. ( ) Check to make sure your transceiver is turned off.

2. ( ) Select a mounting location for your unit.

3. ( ) Remove the mounting template section in this Manual. Use the template to mark the location for the four mounting holes and the hole for the 3-wire cable.

4. ( ) Drill the necessary pilot holes at the locations shown: four 1/8" and a 1/4" hole.

5. ( ) Mount the Auto Patch Encoder to your transceiver with four #4 x 5/16" self-tapping screws.

( ) Identify the wires from the 3-wire cable as follows:

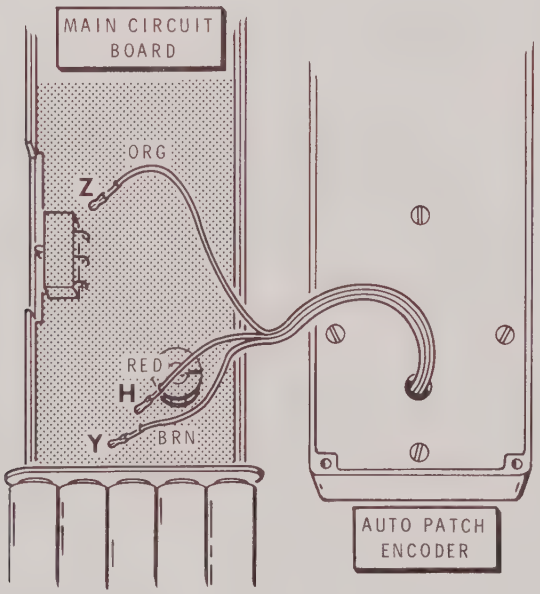
Brown wire: Ground.

Orange wire: B+ in.

Red wire: Two-tone signal out.

( ) Connect each of these wires to the proper location in your transceiver.

This completes the "Installation" of your Auto Patch Encoder.



PICTORIAL 3-4

IN CASE OF DIFFICULTY

The first part of this section of the Manual titled "Visual Tests," describes what to do about the difficulties that may occur right after your unit is assembled.

If the "Visual Tests" fail to clear up the problems, or if difficulties occur after your unit has been in use for some time, read the following information, then refer to the "Troubleshooting Chart."

VISUAL TESTS

1. About 90% of the kits that are returned to the Heath Company for service do not function properly due to poor connections and soldering. Therefore, you can eliminate many troubles by reheating all connections to make sure they are soldered as described in the "Soldering" section of the "Kit Builders Guide."

2. Closely examine each circuit board foil in a good light to see that no solder bridges exist between adjacent connections. If available, use a magnifying glass for this purpose. Remove any solder bridges by holding a clean, hot soldering iron tip between the two points that are bridged until the excess solder flows down onto the tip. Compare your foil pattern against the "X-Ray Views" on Page 25.

3. Check each capacitor value. Be sure that a capacitor of correct value is installed at each capacitor location. Check each tantalum capacitor to be sure the lead near the positive (+) mark is at the correct position.

4. Check each resistor value carefully. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial Diagrams. It would be easy, for example, to install a 100 Ω (brown-black-brown) resistor where a 100 kΩ (brown-black-yellow) resistor should have been installed.

5. Be sure all wires and leads connected to the circuit board have been trimmed as close as possible to the circuit board foils.

6. Try to analyze the symptoms of any problem you may have before starting any troubleshooting procedure. A review of the "Circuit Description" may also help you determine where the trouble is.

If the trouble is still not located after the "Visual Tests" are completed, and a voltmeter is available, check voltage readings against those shown on the "Schematic Diagram" and in the "Circuit Board Voltage Chart." Read the "Precautions for Troubleshooting" before you make any measurement. NOTE: All voltage readings were taken with a high input impedance voltmeter. Voltages may vary as much as ±10%.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Customer Service Information" inside the rear cover of the Manual. Your Warranty is located inside the front cover.

PRECAUTIONS FOR TROUBLESHOOTING

CAUTION: Be very careful when you measure voltages so you do not damage circuit board components.

1. Be sure you do not short any adjacent foils when you make voltage measurements. If the probe should slip, for example, and short together two adjacent connections, it is very likely to damage the transistor or the integrated circuits.

2. Be especially careful when you test a circuit that contains an integrated circuit. Although these components have an almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than many other parts.

Troubleshooting Chart

The following chart lists the "Condition" and the "Possible Cause" of some malfunctions. If a particular part is mentioned as a possible cause, check that part to see if it is incorrectly wired or installed improperly. Also check to see if an improper part was installed at that location. It is also possible, on rare occasions, for a part to be faulty.

CONDITON	POSSIBLE CAUSE
Incorrect tone frequencies are being produced.	1. Incorrect resistor values at R101 through R108 or R111.
*Improper relationship between the amplitudes of the high and the low tones when any keyboard button is being pushed.	1. Incorrect resistor value at R116, R117, or R118. 2. Capacitor C108 not properly soldered to the foil or defective. 3. Capacitor C107 incorrect value or defective.
LED lamp does not light when any keyboard button is being pushed.	1. Transistor Q101 incorrectly installed or defective. 2. LED 101 is installed incorrectly.

*The amplitude of the high tone should not be less than –8 dB lower than the low tone and not more than +4 dB higher.

SPECIFICATIONS

Operating Voltage Range	10.0 to 16.0 VDC.
Current Consumption	16 mA.
Output Level	30 mV rms maximum.
Output Load	10 kΩ minimum.
Frequency Tolerance	±1.5%.
Operating Temperature Range	–20° to +110° F. (–29° to +43° C).
Total Distortion	<5% (harmonic plus intermodulation).
Dimensions	3-3/8" high x 2-1/8" wide x 5/8" deep. (8.6 x 5.4 x 1.6 cm).
Weight	1-1/2 oz. (43 g).

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

CIRCUIT DESCRIPTION

Two identical integrated circuits (IC's) with associated components make up the tone oscillators in the encoder. The low tones are generated by IC101, the high tones by IC102. When one of the keyboard buttons is being pushed, each oscillator produces a tone.

Two or more precision resistors in a divider string are connected between pin 7 of either IC and B+. The R/C constant determined by the value of capacitor C101 and the total resistance value between pin 2 of the IC and B+ determine the frequency of the tone generated in the low tone oscillator. The high tone oscillator operates in the same manner.

The low tone generated in IC101 is filtered by resistor R116 and capacitor C111 and coupled to the input (pin 2) of the amplifier stage, IC103. The values of resistors R121 and R116 determine the voltage gain of the low tone.

The high tone generated in IC102 is filtered by resistor R117 and capacitor C111 and is also coupled to the input of IC103. Resistors R121 and R117 determine the voltage gain of the high tone.

Capacitor C108 provides DC isolation between the amplifier stage and the tone oscillators. Resistor R118 and capacitor C107 provide a DC bias voltage to IC103.

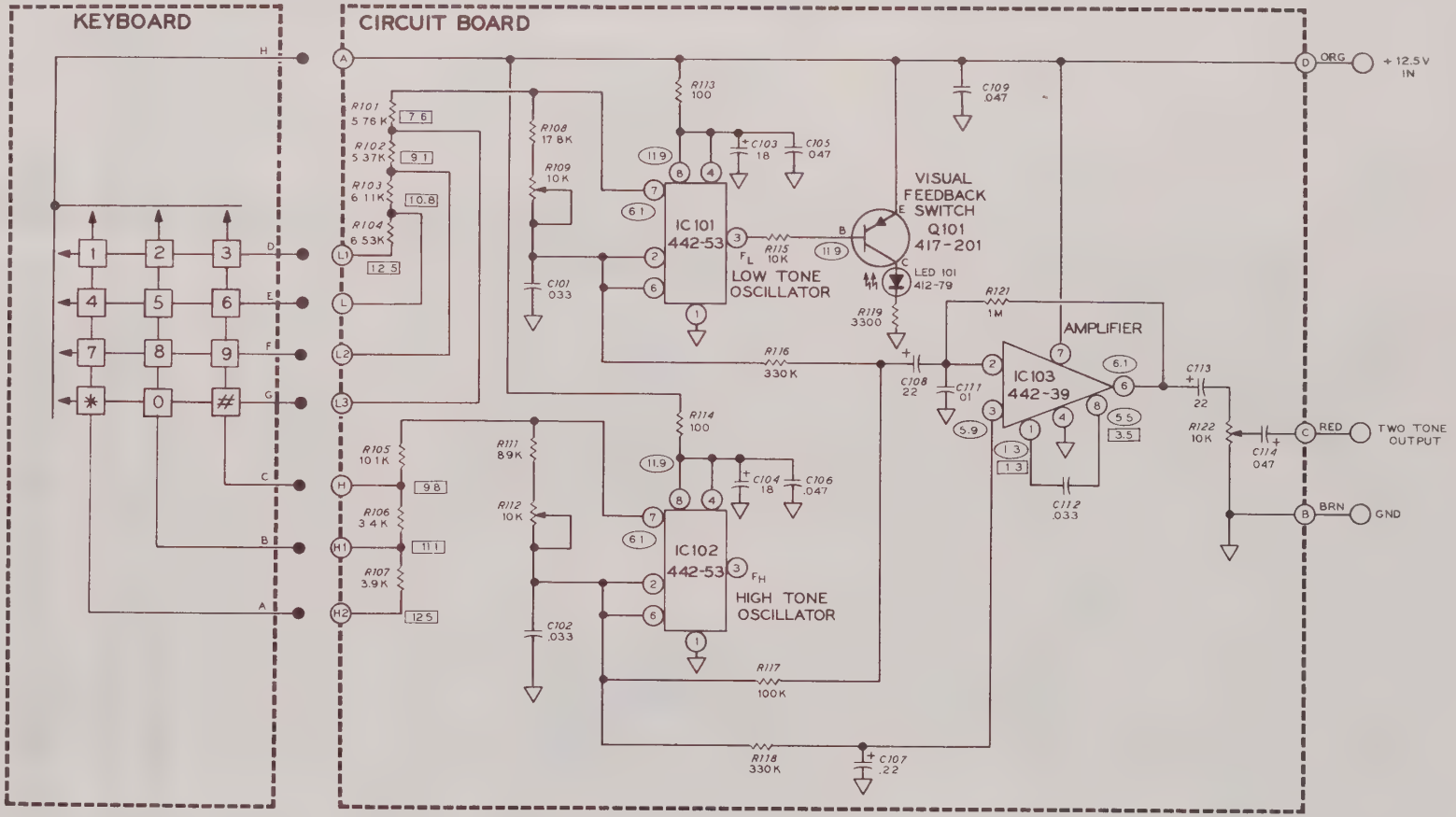
The two-tone signal is also filtered in the amplifier stage, providing a clean signal across level control R122. A portion of this signal is then applied to the modulator stage in the transmitter.

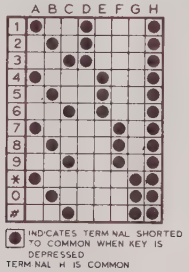
When low tones are generated by IC101, the LED lamp will turn on, indicating that the low tone oscillator circuit is operating.

SCHEMATIC OF THE HEATHKIT® AUTO PATCH ENCODER MODEL HWA-2021-3

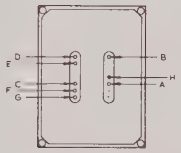
NOTES:

1. REFER TO THE "CIRCUIT BOARD X-RAY VIEWS" FOR THE PHYSICAL LOCATION OF PARTS.
2. PRECISION RESISTORS ARE 1/8 WATT, 1% TOLERANCE. REMAINING RESISTORS ARE 1/4 WATT, 10% TOLERANCE. RESISTOR VALUES ARE IN OHMS (K=1000).
3. CAPACITOR VALUES ARE IN µF.
4. DC VOLTAGE MEASUREMENTS WERE TAKEN WITH A HIGH INPUT IMPEDANCE VOLTMETER FROM THE POINT INDICATED TO CIRCUIT BOARD GROUND. VOLTAGES MAY VARY ±10%.
5. THIS SYMBOL INDICATES A DC VOLTAGE WITH NO TONE BEING PRODUCED.
6. THIS SYMBOL INDICATES A DC VOLTAGE WITH KEY "1" PUSHED.
7. THIS SYMBOL INDICATES CIRCUIT BOARD GROUND.
8. THIS SYMBOL INDICATES A CONNECTION TO THE CIRCUIT BOARD.





● INDICATES TERMINAL SHORTED TO COMMON WHEN KEY IS DEPRESSED
TERMINAL H IS COMMON

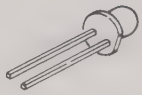
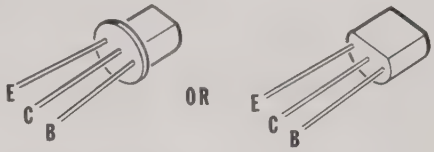
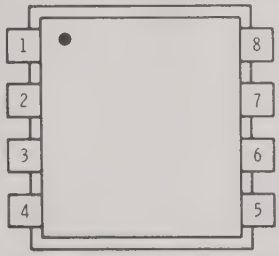
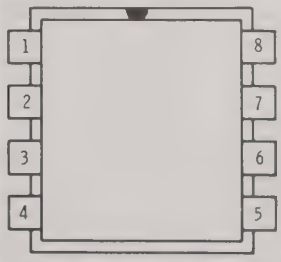


IDENTIFICATION OF KEYBOARD PINS

Low Tone (Hz)	*High Tone (Hz)* 1209	1336	1477
697	1	2	3
770	4	5	6
852	7	8	9
941	*	0	#

Two-tone output frequencies from the Auto Patch Encoder.

SEMICONDUCTOR IDENTIFICATION CHART

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
LED101	412-79	TIL209	
Q101	417-201	X29A829	
IC101, IC102	442-53	NE555V	 (TOP VIEW) 1. GROUND 2. TRIGGER 3. OUTPUT 4. RESET 5. CONTROL VOLTAGE 6. THRESHOLD 7. DISCHARGE 8. V_{CC}
IC103	442-39	LM301A	 (TOP VIEW) 1. OFFSET NULL 2. INVERT INPUT 3. NON INVERT INPUT 4. GROUND 5. OFFSET NULL 6. OUTPUT 7. V_{CC} 8. FREQ. COMP.

CIRCUIT BOARD X-RAY VIEWS

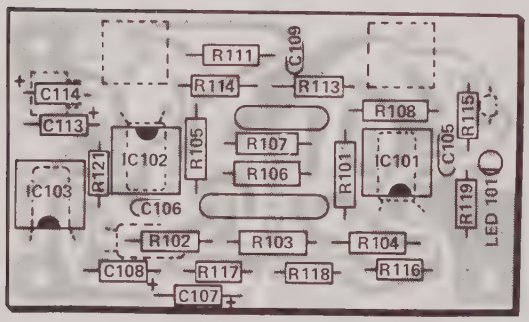
NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

A. Find the circuit component number (R105, C103, etc.) on the "X-Ray Views."

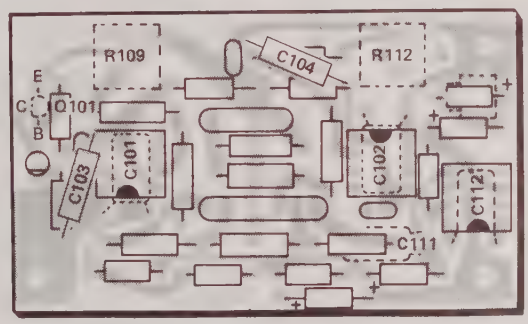
B. Locate this same number in the "Circuit Component Number" column of the "Parts List."

C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.

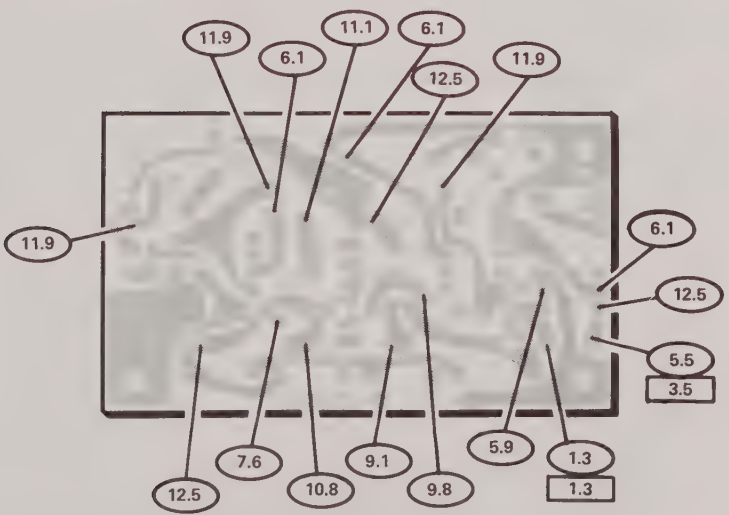
TOP SIDE
(Keyboard side)



BOTTOM SIDE



VOLTAGE CHART



EXPEDITED PARTS ORDER FORM

(FOR REPAIR PARTS ONLY)

PLEASE DO NOT WRITE IN THIS SPACE

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

SEND TO: **HEATH COMPANY**
BENTON HARBOR,
MICHIGAN 49022
ATTN PARTS REPLACEMENT

KIT MODEL	PURCHASE DATE	INVOICE NUMBER	LOCATION PURCHASED

QTY.	HEATH PART NUMBER	DESCRIPTION OF PART	PRICE	TOTAL PRICE	DESIRED METHOD OF SHIPMENT
					EDITORS INITIALS

INSTRUCTIONS:

- INCLUDE CHECK OR MONEY ORDER FOR TOTAL PARTS ORDERED ADD 10% (MINIMUM $0.25) FOR INSURANCE, POSTAGE AND HANDLING.
- AUTHORIZE PERMISSION FOR C.O.D. SHIPMENT (MINIMUM ORDER SHIPPED C.O.D. IS $10.00).
- MICHIGAN RESIDENTS ADD 4% SALES TAX

C.O.D. AUTHORIZATION

_____
SIGNED

THIS FORM IS FOR U.S. CUSTOMERS ONLY. OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR.

CUT ALONG DOTTED LINE

EXPEDITED PARTS ORDER FORM

(FOR REPAIR PARTS ONLY)

PLEASE DO NOT WRITE IN THIS SPACE

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

SEND TO: **HEATH COMPANY**
BENTON HARBOR,
MICHIGAN 49022
ATTN PARTS REPLACEMENT

KIT MODEL	PURCHASE DATE	INVOICE NUMBER	LOCATION PURCHASED

QTY.	HEATH PART NUMBER	DESCRIPTION OF PART	PRICE	TOTAL PRICE	DESIRED METHOD OF SHIPMENT
					EDITORS INITIALS

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C.O.D. AUTHORIZATION

_____
SIGNED

THIS FORM IS FOR U.S. CUSTOMERS ONLY. OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR.

CUSTOMER SERVICE

REPLACEMENT PARTS

If you need a replacement part, please fill in the Parts Order Form that is furnished and mail it to the Heath Company. Or, if you write a letter, include the:

- **Part number** and **description** as shown in the **Parts List.**
- Model number and Series number from the blue and white label.
- Date of purchase.
- Nature of the defect.

Please do not return parts to the factory unless they are requested. Parts that are damaged through carelessness or misuse by the kit builder will not be replaced without cost, and will not be considered in warranty.

Parts are also available at the Heathkit Electronic Centers listed in your catalog. Be sure to provide the Heath part number. Bring in the original part when you request a warranty replacement from a Heathkit Electronic Center.

NOTE: Replacement parts are maintained specifically to repair Heathkit products. Parts sales for other reasons will be declined.

TECHNICAL CONSULTATION

Need help with your kit? . . . . Self-Service? . . . . Construction? . . . . Operation? . . . . Call or write for assistance. You'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek. . .please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit C.O.D. for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

HEATH

Schlumberger

MP MASTER

MA22995

HEATH COMPANY • BENTON HARBOR, MICHIGAN

THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

LITHO IN U.S.A.